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Introduction: Historically, the development of advanced space technology has been accomplished by the federal government providing funding to commercial companies through the standard contracting process. Although recently, commercial space ventures, such as Space X, have begun to develop enhanced commercial space launch capabilities, and many companies provide space related services – including satellite development and operations, advanced technology development still requires (and should require) participation by the federal agency assigned this role – the National Aeronautics and Space Administration (NASA).

However, this standard funding model may not be the most efficient and stable means of developing the advanced technology systems. And while the federal government does not need to be involved in areas where private industry can reasonably operate, it should remain the leader in supporting the development of new and advanced space technologies to further increase our national capability. And as these technologies mature, then private industry can begin the commercialization process, freeing up resources and funds for NASA to develop the next generations of advanced space technology.

In fact, simply examining the last decades of space technology development shows that there is room for improvement. Part of the problem is that there are realistically two space frontiers. There is the commercialization frontier (the realm of Space X and others) and the exploratory frontier (the realm of NASA.) Often technologies that can support the exploratory frontier can also immediately support the commercialization frontier. Yet, these technologies are still developed under the standard model of federal funding and contracting. Is that really the best way to proceed?

In this paper, the argument is put forward that a new process is required, a new paradigm. A consortium of federal agencies as well as commercial companies is needed – in a collaborative rather than a contractual relationship. While many potential forms of this collaborative relationship may be possible, the option proposed here is the establishment of a federally chartered corporation with federal and non-federal ownership. There is precedent for this organizational structure – the United States Enrichment Company (USEC), the Tennessee Value Authority (TVA), etc. The non-federal members may be public and private corporations, educational institutions, as well as other appropriate members as identified in the charter.

To further discuss the potential use of this new relationship, the development of a man rated, type certified Nuclear Thermal Propulsion (NTP) engine is considered. For purposes of discussion, a suggested United States Nuclear Rocket Company (USNRC) is proposed.

To support the development of a man rated NTP engine, a three stage development process (high level schedule) is proposed. The first stage is the development and successful flight of a demonstration mission. Upon attaining that milestone, the development of the needed infrastructure to proceed for man-rating is initiated. Once the man-rating is achieved then the third stage is an obligated buy of a predetermined number of qualified engines for NASA missions.

The first stage is roughly estimated (under one proposed development plan) to cost approximately \$250 million. The intent would be that members of USNRC would provide services, direct funding, facility support and staffing support to offset the cost. While some direct federal funding would be provided by NASA and/or other federal agencies, the entire development cost would not be structured as a federal funded procurement. All members of USNRC would be sharing in the risk and profit potential.

The second stage is roughly estimated to be around \$1 billion in cost. Again, the cost would be shared between all members of USNRC. However, it is expected that the federal government would be a larger investor at this stage due to the successful capability demonstration. Finally, the third stage would be the obligated purchase of a minimum of 6 (estimated) fully qualified nuclear engines by NASA. This would provide sufficient cost recovery to members of USNRC to make the endeavor a commercial success.

It is important to realize that the ultimate milestone for this initial effort - the man-rated engine - would also be considered a type-certified reactor and engine similar to the type certification on nuclear power plants by the U.S. Nuclear Regulatory Commission. There are numerous advantages to a type certification (along with man-rating) and this greatly increases the marketability of the developed engine – and future profitability of USNRC.

As the USNRC would be the owner of the type certification, payments would be made to the USNRC by the companies that produce the engines under contract to the customer. In actuality, this means a company may effectively be paying itself. And while NASA and other federal agencies may not make a profit, fed-

erally funded development costs can be recovered through the construction of any engines developed under license of the USNRC. It is also expected that the USNRC would continue to develop further advanced nuclear engines with funding from partners and licensing fees.

This proposed collaborative process would address many perceived concerns over advanced space systems development. First of all, the risk would not rest solely on the federal government. The development effort could be much more financially efficient. In the end, the same costs to the government would be realized (with the consideration that a more efficient process will mean a more economical solution). The corporate partners would also achieve the same profit and in fact would probably gain more due to the inherent stability that their direct involvement would mean in maintaining the project's course. In addition, Congress would be more amenable to this effort as the risk is mitigated, cost efficiency is increased, the commercial market is supported and NASA is meeting its obligation to advance the exploratory frontier.

Note 1: Fair and open competition would be protected by allowing all authorized companies to become involved in this effort. A broad agency announcement followed by informal and formal working groups would be used to determine the actual corporate members of USNRC.

Note 2: The company name used to illustrate this process also has the same acronym as the U. S. Nuclear Regulatory Commission. It is not expected to be the actual name but just used for discussion purposes.

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